Pathway to Net Zero Carbon Labs

HOK research provides lab owners and developers guidance for reducing operational and embodied carbon to meet net zero goals

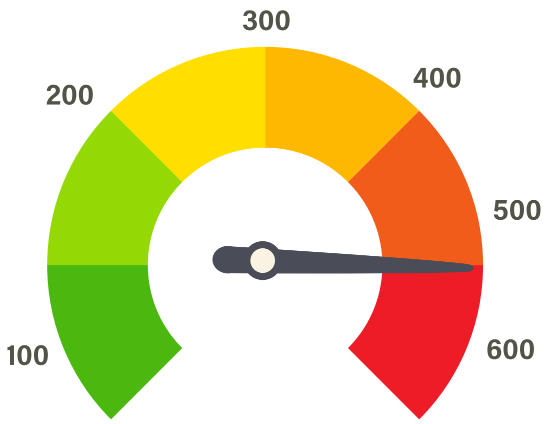
Pathway to Net Zero Carbon Labs

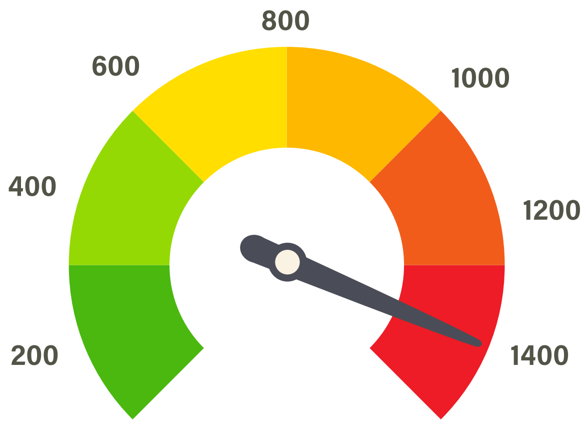
Buildings account for 35-40% of global energy consumption, and few building types consume as much energy as scientific labs. To help lab owners and developers reduce their carbon footprint, HOK's Science + Technology team conducted extensive analysis examining how lab buildings can significantly reduce their carbon dependency and, with the addition of on-site renewables and off-site offsetting, achieve net zero.

The Challenge

The carbon intensity of labs has presented designers with a unique challenge. These highly complex facilities demand far greater ventilation than most building types and are home to highly energy-intensive equipment that is often in operation 24 hours a day. Labs also need robust structural systems to limit building vibration and support heavy building loads. Structural systems, typically comprised of concrete and steel, contain high volumes of embodied carbon, i.e., the energy expended in the base material extraction, manufacturing and transportation of building materials. The result is that labs require far more energy to build and operate than most other building types.

Lab Building Energy Consumption Benchmark





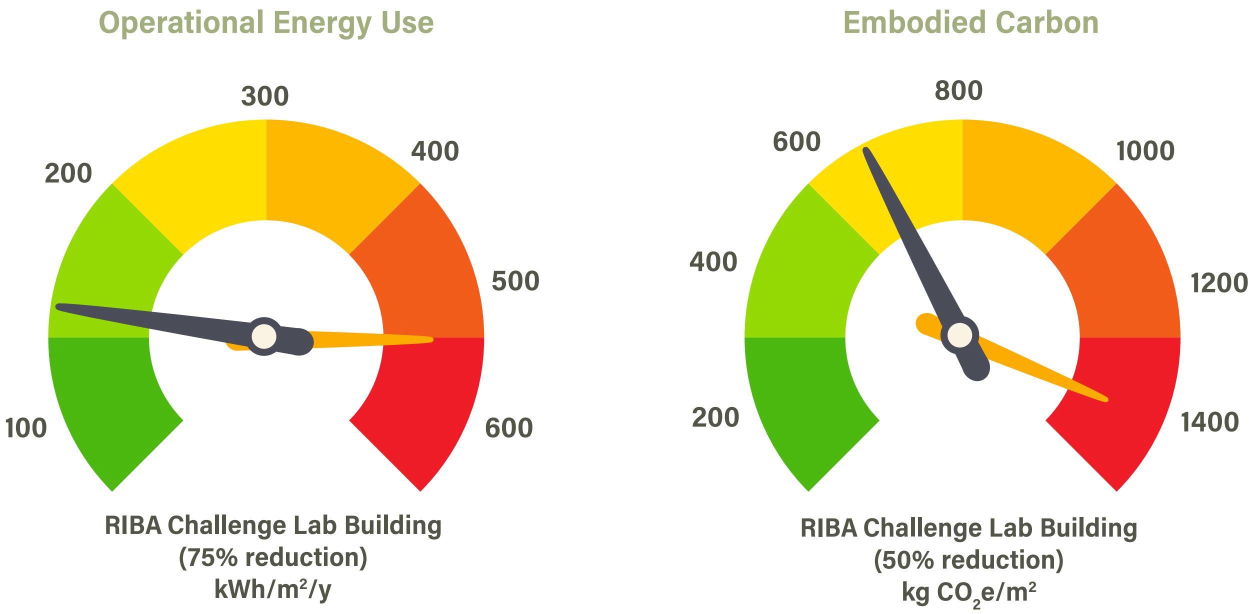
Poor performers: The typical lab building requires 589 kWh/m^2/y of energy to operate (S-Labs Benchmark) and contains 1400 kgCO_2e/m^2 of embodied carbon (RIBA 2030 Challenge Non-Domestic Benchmark). Both performance measures place lab buildings at odds with widely accepted sustainability goals.

Today the benchmark operational energy use for a modern research lab today stands at 589 kilowatt hours per square metre annually (kWh/m^2/y). By comparison, the annual benchmark energy use for a commercial office building stands at 130 kWh/m^2/y, and the benchmark for residential buildings is 120 kWh/m^2/y. When it comes to embodied carbon, it's not uncommon for lab buildings to contain twice the built-in carbon of other building types.

The Goal

Given the imminent threat of climate change, can labs be built and operated in a manner that is significantly less harmful to the environment? Particularly, can lab buildings achieve net zero status by 2030 as set out by the design challenges of both the Royal Institute of British Architects (RIBA) and the American Institute of Architects (AIA)? Those are the key questions of HOK's analysis.

Lab Building Energy Consumption 2030



Dial it down: To meet the guidelines of the RIBA 2030 Challenge, lab buildings would need to reduce their operational consumption by 75% (to 147 kWh/m^2/y) and embodied carbon by 50% (to 700 kgCO_2e/m^2).

Using the RIBA 2030 Challenge as a target, HOK explored how lab buildings could reduce their operational energy use by 75%—from 589 kWh to 147 kWh/m^2/y—and embodied carbon 50 percent from—1400 kgCO_2e/m^2 to 700 kgCO_2e/m^2 or lower.

Analysis and Results

Operational Energy

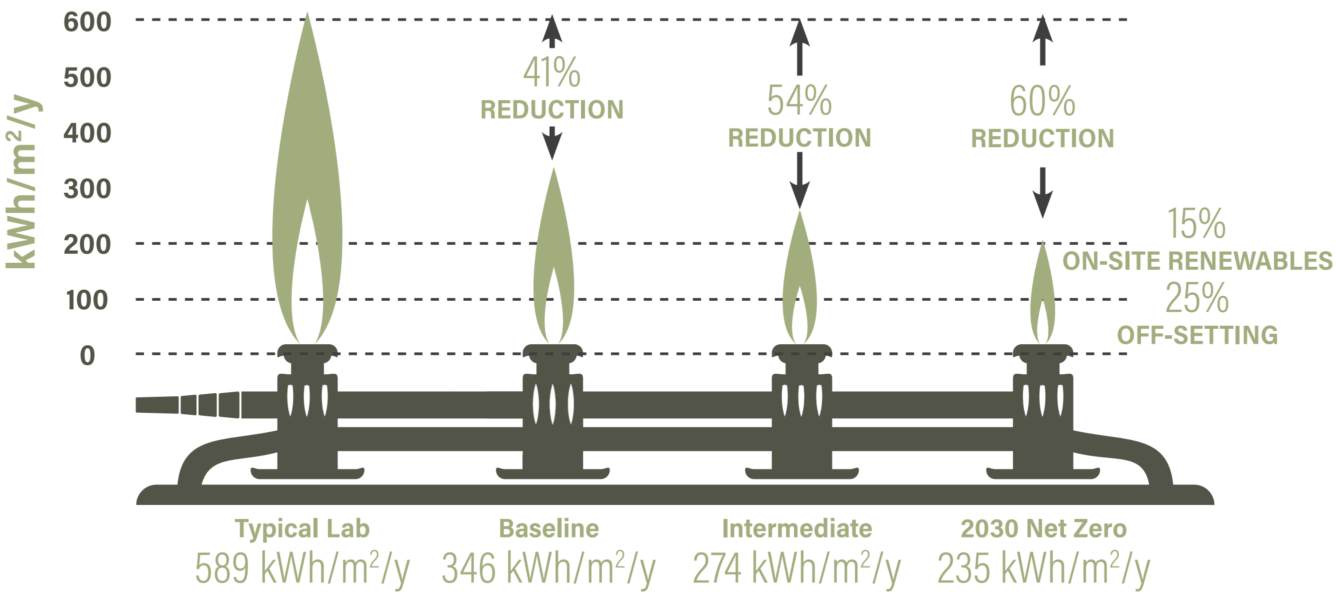
HOK analyzed two different lab building forms—a vertical lab akin to those found in city centers and a linear lab more typical of suburban settings. These lab types were modeled to assess how they perform under the following three energy design approaches:

1. **Baseline Practice:** This approach incorporates performance specifications greater than current building regulations while using products that are still commercially competitive, for example high performance double glazing. This approach also assumes an average ventilation rate of 6 air changes per hour (ACH).

2. **Intermediate Practice:** This approach improves upon the baseline practice by increasing performance specification to the next commercially available level, for example using high performance double glazing with a krypton filled cavity. This approach assumes an average air change per hour of 5.

3. **2030 Net Zero Practice:** This approach uses back-stop performance specification to achieve net-zero certification. For example, where the intermediate approach would use double glazing with krypton cavities, 2030 Net Zero would use triple glazing. Ventilation rates under this approach would be kept to 4 ACH.

Operational Energy Use



HOK's analysis found it is possible to reduce operational energy consumption 60% off the current benchmark. On-site renewable energy sources could offset energy demand another 15% to achieve a 75% reduction before additional offsetting.

Our findings from the three approaches studied revealed the 2030 Net Zero specification reduced energy consumption the most—by 60% through a combination of improvements to air tightness, insulation, glazing performance, shading and, most importantly, lowering the number of average air changes to 4 per hour. These adjustments to the net zero specification would bring energy consumption from the grid down to the targeted goal of 235 kWh/m^2/y before on-site renewables and offsetting. The energy modelling assumptions made here also assumed an on-site energy provision through renewables, such as photovoltaics and ground source heat pumps (GSHP), that would reduce grid demand by 15% to 147 kWh/m^2/y. An additional 25% reduction in energy would have to come from certified offsetting programs—a necessary requirement until the energy grid itself is decarbonized.

Embodied Carbon

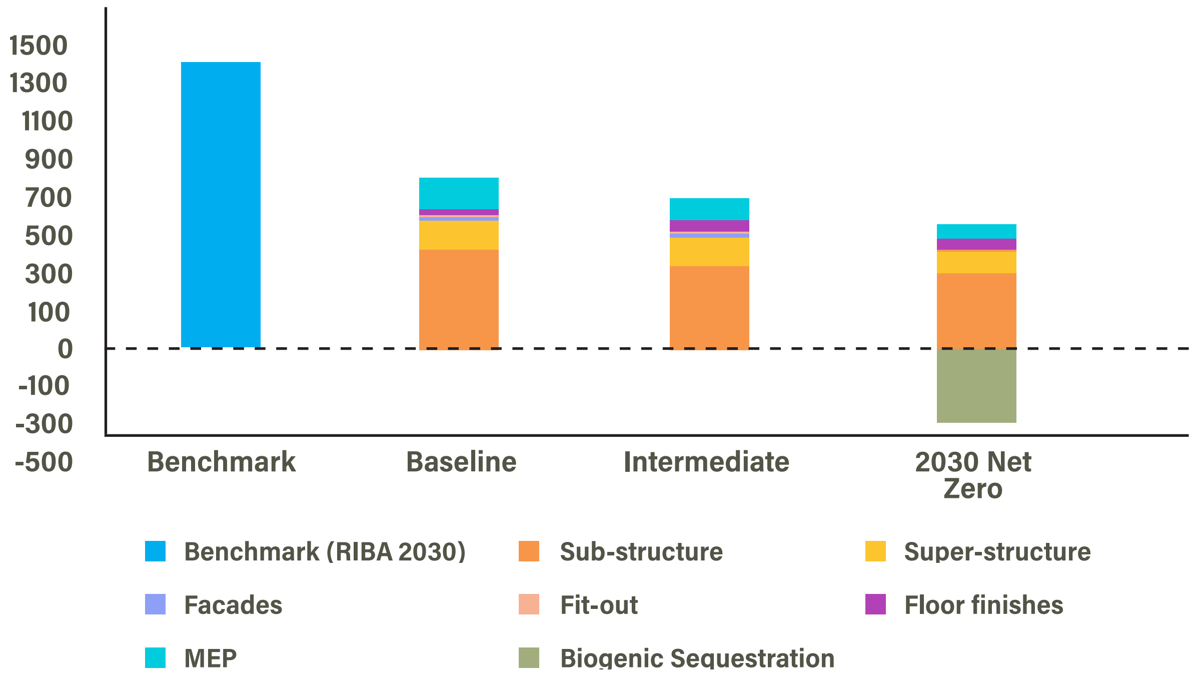
In conjunction with our energy reduction studies, HOK examined three construction method approaches to determine which offered the lowest embodied (construction) carbon. The three construction options studied were:

1. **Baseline Practice:** This design would feature a steel and pre-cast concrete structural system with low carbon concrete. The façade for this approach would use a PPC aluminum panel system with composite timber and aluminum framed fenestration. The fit out would include limited suspended ceilings, limited raised floors, screed and resin flooring, aluminum glazed partitions and paintings and coating with low or no off-gassing.

2. **Intermediate Practice:** This design approach would incorporate a low carbon concrete structural system and use a pre-cast concrete unitized façade system with PPC aluminum fenestration. Fit out would include suspended ceilings, raised floors, aluminum glazed partitions and industry standard paints and coatings.

3. **2030 Net Zero Practice:** This design would use a mass timber structural system with screed topping, a timber cladding system and full timber framed fenestration. Fit out would have no suspended ceilings or raised floors (the screed floor will be exposed with a polished finish).

Embodied Carbon Analysis



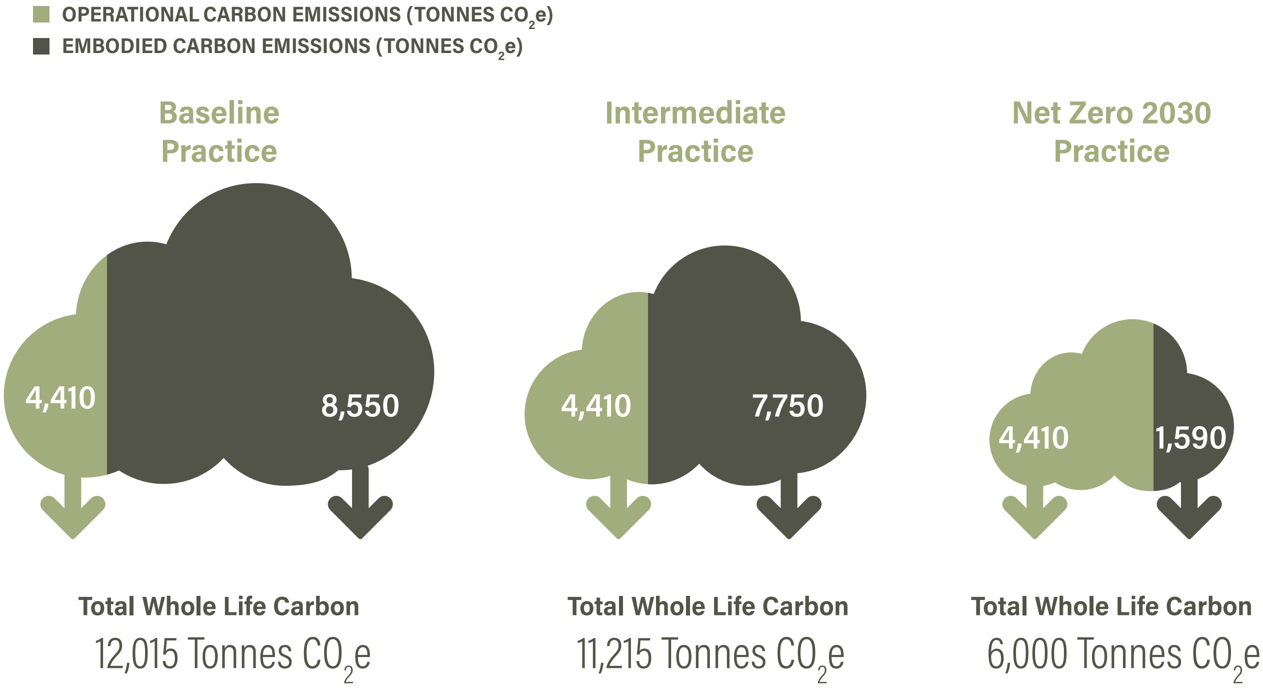
HOK's analysis indicates that the timber-based approach was most effective at reducing embodied carbon.

While all three approaches reduced embodied carbon, the 2030 Climate Challenge option had the lowest embodied carbon at 547 $kgCO_2e/m^2$, falling within RIBA's 2030 Challenge target. If we included the carbon sequestration of the timber (the amount of carbon absorbed from the environment and stored during the growing of the trees) the embodied carbon would drop even further to around 141 $kgCO_2e/m^2$ —a 90% reduction from the benchmark.

Conclusion + Considerations

HOK's initial analysis indicates that, while not easy, it is possible to build and operate labs in accordance with the sustainable design goals of the RIBA and AIA 2030 challenges. Altogether, the approaches studied in this analysis can significantly reduce the whole-life carbon (operational carbon + embodied carbon × building lifespan) of a lab building.

Commercial Lab Whole Life Carbon Results



By reducing embodied carbon, labs can 'flip the script' wherein the building of the lab would no longer create a greater carbon footprint than its year-to-year operation. The charts above show whole-life carbon over a 30-year time span on a 10,000m² building.

In general, HOK's modelling showed little difference between vertical and linear lab buildings in achieving net zero. Linear labs do hold one distinct advantage: Their expansive roofs allow for more solar panel arrays. It is important to note that our analysis examined new lab buildings, but the most sustainable option is to reuse and adapt existing buildings. This 'retrofit first' principle will save over 500 $kgCO_2e/m^2$ of embodied carbon without the use of limited global timber supply. It is our best way to achieve net zero carbon for our sector.

HOK is now studying how labs can achieve targeted operational carbon goals while allowing for more than 4 air changes per hour. Additional HOK research underway includes an analysis of the embodied carbon of lab MEP systems, a renewables feasibility study, and net zero costs and savings compared with business as usual. Look for those findings in coming months.

HOK's London, New York and San Francisco offices contributed to this study. Download the full report here. For more information or questions, contact Gary Clark, regional leader of Science + Technology or Rob McGill, sustainable design leader, in our London studio.

Rob McGill

Sustainable Design Leader, HOK London Studio

Gary Clark

Principal Regional Leader of Science & Technology, HOK London Studio
Honorary Professor of Sustainable Architecture, Queens University, Belfast
Past-Chair of RIBA Sustainable Futures Group
Member of Construction Industry Council Expert Panel on Climate Change